antiferromagnetically biased sensor elements, the central aspect of this invention is not the provision of the particular structural forms that comprise these sensor types. Rather, the present invention provides a novel double-layer seed layer formation that is shown to enhance the magnetoresistive properties of any and all of these particular sensor formations. The double-layer seed layer provided by the present invention comprises a first material layer formed of material selected from nickel-chromium alloys or nickel-iron-chromium alloys and a second material layer, which is a very thin layer (5-15 angstroms) of nickel oxide, which, at this thickness, has dielectric properties but, advantageously, has no magnetic properties. Although nickel-chromium alloys and nickel-iron-chromium alloys, when used alone, are known in the art to provide seed layers which improve the properties of magnetoresistive sensor elements, the novel addition of a thin, non-magnetic nickel oxide layer formed over those alloys is found to improve the magnetoresistive properties of a variety of sensor elements still further as compared to such sensor elements formed using only the single layer seed layer. While the precise role of the nickel oxide material layer is not known, it appears to both enhance the lattice matching to the NiFe layer in the sensor element and to enhance specular reflection of conduction electrons within the sensor. The fact that a significant improvement in sensor characteristics can be obtained by the addition of so thin a nickel oxide layer is particularly advantageous. It has been shown that the 5-15 angstrom layer provides an improvement in sensor performance comparable to that associated with the deposition of substantially thicker layers (200 angstroms and greater) of nickel oxide which, at those thicknesses, have antiferromagnetic properties which may neither be

desirable nor necessary and which also add significantly to the thickness of the sensor element.

Having outlined the basic features of the invention set forth in the present application, Applicants would like to address the objections of the Patent Examiner in the numerical order in which they are set forth in the Detailed Action.

Sections 2 and 3.

Reconsideration of the rejection of Claims 1-22, wherein claims 1, 4, 6, 8, 13, 15, 17 and 18 are amended herein and claims 2 and 14 are cancelled herein, under 35 U. S. C. 103 (a), as being unpatentable over Gill et al. (U. S. Patent No. 5701222) in view of Lee et al. (U. S. Patent No. 6141191) is requested in light of the following arguments.

As pointed out correctly by the Examiner, Gill shows a GMR sensor element and a SVMR sensor element comprising a substrate, a seed layer formed over the substrate and a nickel oxide material layer formed over the seed layer. Lee shows a seed layer being formed of MR enhancing materials selected from among nickel-chromium alloys and nickel-iron-chromium alloys. The combination of Gill's GMR formation and Lee's seed layer materials, however, does not provide a sensor formation having the double-layer seed layer of the present invention. The thin (5-15 angstrom) nickel oxide material layer within the double-layer seed layer of the present invention is not analogous to the nickel oxide material layer shown as layer 47 in Fig's 3a and 3b of Gill et al. Gill specifically sets forth the role of nickel oxide layer 47 in the following words: "Since the spacer layer 47 also serves to electrically isolate the first spin valve 36 from the second spin valve 38, it must be an electrically insulating material as well as an

antiferromagnetic material, such as NiO." (Gill, column 6, lines 55-59). Since Gill desires that the NiO layer be an antiferromagnetic layer, he forms it to a thickness of 400 angstroms (Gill, column 7, line 8). To achieve the antiferromagnetic properties of NiO, it must be formed to a thickness of at least 200 angstroms, and is 400 angstroms in Gill's sensor element. The present invention does not wish the NiO layer to be antiferromagnetic, but rather to have no magnetic properties whatsoever. To this end, in the present invention it is formed to a thickness of between 5 and 15 angstroms. Applicants would claim that the NiO material layer of Gill serves an entirely different purpose than the NiO layer in the double-layer seed layer provided by the present invention, namely the NiO layer of Gill is used "to produce an effective magnetic field... in the pinned layer... by exchange coupling" (Gill, column 6, line 35). It would, therefore, not be obvious to one of ordinary skill that the 400 angstrom thick NiO layer of Gill could or should be reduced to a thickness of between 5-15 angstroms, since a reading of Gill presents the NiO layer as an antiferromagnetic layer, whereas the reduction of its thickness would destroy that precise property that Gill is trying to achieve. In short, there is a crucial distinction between a 400 angstrom NiO layer and a 5-15 angstrom NiO layer, not simply because of the fact that the thinner layer produces a thinner sensor element, but because the thinner layer has different physical properties and performs a different role within the sensor formation.

The Examiner claims that it would have been obvious to form the NiO layer to a thickness of between 5 and 15 angstroms as a non-magnetic layer. Examiner further suggests that the rationale for such a change in layer dimension involves "routine experimentation" in order to enhance exchange coupling between a ferromagnetic layer

and an NiO layer. Applicants would instead claim that the discovery of a change from a layer with antiferromagnetic properties to one with no magnetic properties is hardly the stuff of "routine experimentation," but rather the result of novel thinking and inventive innovation of the sort that the patent laws are designed to protect. Furthermore, since Applicants were not seeking to enhance exchange coupling, as was Gill, but were seeking to enhance lattice matching and specular reflection of conduction electrons, there would be no purpose in such routine experimentation, nor would a reading of Gill and Lee together suggest that such routine experimentation either should be carried out or could be carried out successfully.

Accordingly, amendments to the patent application have been made herein in order to emphasize the distinction between the single, 400 angstrom thick NiO layer of Gill and the 5-15 angstrom thick NiO layer which is part of a double-layer seed layer in the present invention. In particular, independent claims 1, 6, 13 and 17 now specifically claim the seed layer as a double-layer comprising a first nickel-chromium alloy layer or nickel-iron-chromium alloy layer and a second non-magnetic nickel oxide layer. Applicants feel that the role of the nickel oxide layer as a part of the seed layer and playing the role of a seed layer is a critical distinction that must be drawn with Gill, wherein the nickel oxide layer is deposited as a material layer that serves a purpose other than being a seed layer. Applicants also argue that all claims of the present invention that involve either the sensor element formation method or the sensor element fabricated through use of the method are, therefore, novel and should be allowed.

Section 5.

We wish to thank the examiner for pointing out the following pertinent prior art made of record and not relied upon.

Aoshima et al. (U. S. Patent No. 6046894) discloses an MR head comprising an NiFeCr underlayer (ie. a seedlayer) and an antiferromagnetic layer formed on said underlayer. As is the case with the method of Gill, the antiferromagnetic layer does not anticipate the non-magnetic NiO layer of the present invention. Therefore, while we note with interest the reference, we do not feel that it materially affects the allowability of the present invention.

Attached hereto is a marked-up version of the changes made to the title and claims by the current amendment. The attached page is captioned:

Version with markings to show the changes made."

The Examiner is thanked for thoroughly reviewing the application. All claims discussed above are now believed to be allowable. If the Examiner has any questions regarding the above application, please call the undersigned attorney at 845-452-5863

Respectfully submitted,

Stephen B. Ackerman, Reg. No. 37,761

VERSION WITH MARKINGS TO SHOW THE CHANGES MADE

PLEASE AMEND THE TITLE AS FOLLOWS:

GIANT MAGNETORESISTIVE (GMR) SENSOR ELEMENT WITH ENHANCED MAGNETORESISTIVE (MR) [COEFICIENT] <u>COEFFICIENT</u>

PLEASE AMEND THE CLAIMS AS FOLLOWS:

Please cancel claim 2.

Please cancel claim 14.

Please amend claim 1 as follows:

Claim 1. (AMENDED) A method for forming a giant magnetoresistive (GMR) sensor element <u>with an enhanced magnetoresistive coefficient</u> comprising:

providing a substrate;

forming over the substrate a <u>double-layer</u> seed layer, [the seed layer being formed of a] <u>said double layer comprising</u> <u>a first material layer selected</u> <u>from the group of</u> magnetoresistive (MR) resistivity sensitivity enhancing material [selected from the group] consisting of nickel-chromium alloys and nickel-iron-chromium alloys <u>and said double-layer seed layer further comprising a second material layer, said material layer being a thin, non-magnetic dielectric nickel oxide material layer that additionally enhances magnetoresistive (MR) resistivity sensitivity</u>;

[forming over the seed layer a nickel oxide material layer;]

forming over the [nickel oxide material] double-layer seed layer a free ferromagnetic layer;

forming over the free ferromagnetic layer a non-magnetic conductor spacer layer;

forming over the non-magnetic conductor spacer layer a pinned ferromagnetic layer; and

forming over the pinned ferromagnetic layer a pinning material layer.

Please amend claim 4 as follows:

Claim 4. (AMENDED) The method of claim 1 wherein the nickel oxide material layer, which is the second material layer of said double-layer seed layer, is formed to a thickness of from about 5 to about 15 angstroms as a non-magnetic dielectric nickel oxide material layer.

Please amend claim 6 as follows:

Claim 6. (AMENDED) A giant magnetoresistive (GMR) sensor element with an enhanced magnetoresistive coefficient comprising:

a substrate;

a double-layer seed layer formed over the substrate, [the seed layer being formed of a] said double layer comprising a first material layer selected from the group of magnetoresistive (MR) resistivity sensitivity enhancing material [selected from the group] consisting of nickel-chromium alloys and nickel-iron-chromium alloys and said

double-layer seed layer further comprising a second material layer, said material layer being a thin, non-magnetic dielectric nickel oxide material layer that additionally enhances magnetoresistive (MR) resistivity sensitivity;

[a nickel oxide material layer formed over the seed layer;]

a free ferromagnetic layer formed over the [nickel oxide material] double-layer seed layer;

a non-magnetic conductor spacer layer formed over the free ferromagnetic layer;

a pinned ferromagnetic layer formed over the non-magnetic conductor spacer layer; and

a pinning material layer formed over the pinned ferromagnetic layer.

Please amend claim 8 as follows:

Claim 8. (AMENDED) The giant magnetoresistive (GMR) sensor element of claim 6 wherein the nickel oxide material layer, which is the second material layer of said double-layer seed layer, is formed to a thickness of from about 5 to about 15 angstroms as a non-magnetic dielectric nickel oxide material layer.

Please amend claim 13 as follows:

Claim 13. (AMENDED) A method for forming a spin valve magnetoresistive (SVMR) sensor element with an enhanced magnetoresistive coefficient comprising:

providing a substrate;

forming over the substrate a double-layer seed layer, [the seed layer being formed of a] said double layer comprising a first material layer selected from the group of magnetoresistive (MR) resistivity sensitivity enhancing material [selected from the group] consisting of nickel-chromium alloys and nickel-iron-chromium alloys and said double-layer seed layer further comprising a second material layer, said material layer being a thin, non-magnetic dielectric nickel oxide material layer that additionally enhances magnetoresistive (MR) resistivity sensitivity;

[forming over the seed layer a nickel oxide material layer;]

forming over the [nickel oxide material] double-layer seed layer a free ferromagnetic layer;

forming over the free ferromagnetic layer a non-magnetic conductor spacer layer;

forming over the non-magnetic conductor spacer layer a pinned ferromagnetic layer; and

forming over the pinned ferromagnetic layer a pinning material layer.

Please amend claim 15 as follows:

Claim 15. (AMENDED) The method of claim 13 wherein the nickel oxide material layer, which is the second material layer of said double-layer seedlayer, is formed to a thickness of from about 5 to about 15 angstroms as a non-magnetic dielectric nickel oxide material layer.

Please amend claim 17 as follows:

Claim 17. (AMENDED) A spin valve magnetoresistive (SVMR) sensor element with an enhanced magnetoresistive coefficient comprising:

a substrate;

a double-layer seed layer formed over the substrate, [the seed layer being formed of a] said double layer comprising a first material layer selected from the group of magnetoresistive (MR) resistivity sensitivity enhancing material [selected from the group] consisting of nickel-chromium alloys and nickel-iron-chromium alloys and said double-layer seed layer further comprising a second material layer, said material layer being a thin, non-magnetic dielectric nickel oxide material layer that additionally enhances magnetoresistive (MR) resistivity sensitivity;

[a nickel oxide material layer formed over the seed layer;]

a free ferromagnetic layer formed over the [nickel oxide material] double-layer seed layer;

a non-magnetic conductor spacer layer formed over the free ferromagnetic layer;

a pinned ferromagnetic layer formed over the non-magnetic conductor spacer layer; and

a pinning material layer formed over the pinned ferromagnetic layer.

Please amend claim 18 as follows:

Claim 18. (AMENDED) The spin valve magnetoresistive (SVMR) sensor element of claim 17 wherein the nickel oxide material layer, which is the second material layer of

said double-layer seedlayer, is formed to a thickness of from about 5 to about 15 angstroms as a non-magnetic dielectric nickel oxide material layer.